Superabsorbent Polymer: Synthesis and Characterization

SHORT SYNOPSIS

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DOCTOR OF PHILOSOPHY

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Registration number: 2K20-PFS-001

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(FORMERLY MANAV RACHNA COLLEGE OF ENGINEERING
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ABSTRACT

In the proposed research work synthesis of superabsorbent and different type of graft copolymer will be synthesized by solution and graft-copolymerization All polymerization reaction will carry out in inert atmosphere. Neutralization of monomer using NaOH in cooling atmosphere and maintain the degree of neutralization throughout the reaction Initiator will introduce into the reaction to start polymerization Clear solution of polysaccharides will prepare Reaction will proceed at 70ºC and stirring speed is 600 RPM For termination step oxygen will introduce in the reaction Ethanol will use for washing of SAP and dry in hot air oven at 100ºC.

Keywords- Superabsorbent polymers, solution polymerization, absorbency under load,

FTIR, SEM, Composites

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1. Introduction

Superabsorbent polymer or hydro gels are cross linked; three dimensional hydrophilic polymeric structure and it consist of ionic functional group. Superabsorbent are white hydroscopic material and consist of ionic monomers and are characterized by various studies [1]. The 3-D structure of SAPs is prepared by the use of cross linker process. Due to its ionic structure, its capacity to absorb water and dulcet solution and its swell up to thousand type their mass. This absorbed solution or water is hardly removable under pressure. Due to good absorbency of superabsorbent, it widely used for preparation for diaper, famine napkin and agriculture soil and horticulture purpose [2-5]. They are widely used in various fields like hygienic food, cosmetics, medicines and biotechnology etc. The variation in natural polymer leads to formation of new products and this newly formed material are hydrogel, which have high absorbency and mechanical strength [6]. Superabsorbent polymer classifies in to two categories synthetic and natural, the natural polymers are generally consisting of polysaccharides and it shows property of biocompatible. The natural type superabsorbent hydrogel, which can be synthesize by co-polymerization and conjoin of copolymer and homopolymer. The hydrogel which are acknowledge to electric field, heat and pH, it is known as smart hydrogel or intelligent hydrogel [7]. The acrylic base SAPs been used in biomedical research due to their good swelling behavior and chemical stability. The pH senstive hydrogel used in such cases like delivery of drug in specific reason of gastrointestinal tract. SAPs are generally non-toxic, biocompatible and biodegradable [8]. There are various application of superabsorbent like wrapping inside communication cable, having ability to absorb water from environment, hence protect the cabels. The application of superabsorbent in various fields like tissue engineering agriculture medicine, drug delivery, food industries, thermal energy storage, horticulture, sealing composites, biosensors, etc [9-17]. Owing to their unique properties (SAPs) and thus facilitating their use in certain applications [18], diminish autogenously shrinkage [19-21], altering the theology of fresh real [19, 20], self-sealing and self-healing of fractured real [22-30]. As chemically, they are classifying in to two kind ionic and non-ionic SAPs [31]. The characteristic properties of SAPs mostly ionic polymer which absorb immense of water and solution. Other distinguishes, based on the type of cross-linker takes place between the polymer chains: ionic, covalent or H_2 bond [32]. The covalent cross linkers are strong and stable and extensively used in concrete and mortar. The essential part of cross linker of SAPs are type of bond which prevent SAPs. The synthetic SAPS have superior

quality than natural based polymer. The recently used SAPs are semi synthetic which are infibres form or powder form. The natural based polymer absorb little amount of liquid and body fluids while absorbent material which consist of natural polymer. It shows most important characteristics properties and it is biodegradable in nature. In ancient time, cotton and wipe were used as porous resources [33, 34].

2. Review of Literature

A number of papers have been available in the views of SAP and hydro gels materials. Generally, authors mostly paying attention on the real methods and property of the SAPs. In case of physical and chemical method of prepare agricultural hydrogels, Kazanskii and Dubrovskii Bouranis et al. reviewed the real polymers as soil conditioners. They included interpenetrating networks; soil conditioning polymers based blends and also polymers collective with unhurried release compound as well as transformable resources. In this, polar group were present on the chain of water soluble conditioners and main functioning of conditioners to stabilize the soil structures and the water retuning agent were most of hydrophilic polymers [35]. A review was performed on super absorbents obtained from shellfish waste. Due to Increase worldwide require for absorbent materials for individual concern and medical field create an opportunity for basic research towards the growth of porous resources and system with extra profit such as highly absorbing material At presently available synthetic superabsorbent are not biodegradable. This research work provides in order about new SAPs based on chitson salts training and their property. For the research of absorbent material, chitin is a good choice as a substrate & possibility of waste. Elevated gel power of salts such as chitosan expressed by elevated absorbency below pressure. A paper was published in which chitin derivatives was found as biodegradable in nature [36]. Athawale et al. described gelatinized starch grafted copolymerization with acrylic acid by using super-absorbent resin. This research work focus on water absorbing resins that were based on gelatinized starch and graft co-polymers of acrylic acid. It described the synthesis of these SAPs and commercial application of these hydrogel. In the water absorbing capacity of these SAPs based on gelatinized build (starch) grafted by monomer (acrylic acid) showing maximum H_2O absorption. The previous research work on these SAPs explore about increasing H_2O absorption, H_2O free controlled process, asset H_2O below pressure and its absorption during presence of electrolyte and hence these property create

the manufactured goods helpful for commercial purpose [37]. The super absorbent materials based polysaccharides and proteins were also reviewed by Ichikawa and Nakajima [38]. Buchholz et al. has elucidate the cross linked starch-based SAPs via partially neutralized acrylic acid (poly) grafted copolymerization with starch [39]. Safaei et al. has also elucidate an effort to explore the control of polymerization parameter like attention of monomer, % neutralization, the presence of agent (porogen) perlite and content of bulge properties based on acrylic acid and SAPs. The study also paying attention on the AUL of the ready SAPs. In this, the field FESEM was used to assess SAPSs morphology while energy dispersive was used to examine dispersal of perlite into the SAPs. Also, acrylic acid monomer based SAPs containing perlite particles were synthesize through gas blow process. Dayal et al. described about synthesizes on acrylic superabsorbents, containing polymerization solutions and suspension polymerization. Ricardo et al. documented the H_2O porous polymers in agreement with the synthesis. Also, a book described about high H_2O amalgamation of textiles and fibers. Dhodapkar et al. review the SAPs from aqueous solution. Jianzhong et al. report the new development on superabsorbent hydrogels based on cellulose which investigated different approaches for preparation and employed in synthetic and future research promising applications. Also, provides contribution towards the cellulose-based superabsorbent SAPs manufacture approach, resources and gifted application. In this, different synthesis method was introduced and SAPs based on cellulose have different properties such as hydrophillicity, biocompatibility, transparency, low cost & non-toxicity and its application in agriculture, personal health care, biomedical etc. However, some fields to be expanded such as oil plugging agent, electrochemistry. The review of literature and the latest findings suggest that several conducting polymers had been optimized with guar gum. fabricated a ternary composite of PTh/ α-Fe_2O_3/ modified nafion glassy carbon electrode (GCE) for detection of liquid methanol as a novel electrochemical sensor. Successfully synthesized GCE modified with camphor sulfonic acid surfactant assisted SAPs using an in-situ chemical oxidative polymerization method for electrochemica highly flexible organic electrochromic device built using guar gum with vinyl monomers as active materials.

3. Description of Broad Area

Superabsorbent polymer or hydro gels are cross linked; three dimensional hydrophilic polymeric structure and it consist of ionic functional group. Due to its ionic structure, its capacity to absorb water and dulcet solution and its swell up to thousand type their mass. This absorbed solution or water is hardly removable under pressure.

4. Objective of Study

Superabsorbent polymer or hydro gels are cross linked; three dimensional hydrophilic polymeric structures and it consist of ionic functional group. This makes them preferably suitable as absorbents of corpse fluid in various goods. The proposed research work will be followed by points given bellow

I. To synthesis a new SAPs using various polysaccharides and vinyl monomers.
II. Solution Polymerization and Graft copolymerization will use for synthesis of SAP materials.
III. FTIR/TGA/SEM analysis of various type of SAP materials
IV. To study the absorption capacity of the material by using free absorption capacity (FAC) and absorbency under load (AUL).
V. To study the change in properties in presence of various salts.

5. Methodology to be adopted

1. Solution polymerization technique adopted for synthesis of SAP material.
2. All polymerization reaction will carry out in inert atmosphere.
3. Neutralization of monomer using NaOH in cooling atmosphere and maintain the degree of neutralization throughout the reaction
4. Initiator will introduce into the reaction to start polymerization
5. Clear solution of polysaccharides will prepare
6. Reaction will proceed at 70ºC and stirring speed is 600 RPM
7. For termination step oxygen will introduce in the reaction
8. Ethanol will use for washing of SAP and dry in hot air oven at 100ºC

6. Expected Outcome of the Research

1. Polymer-Polysaccharides based biodegradable superabsorbent
2. To develop new superabsorbent, cost-effective will use in daily products
3. Platform to use inverse suspension polymerization attractive method to synthesis SAPs in powder from.
4. To produce and publish high-quality scientific research papers

7. References

1. Mignon A, Belie DN, Dubruel P, Vlierberghe VS, *Superabsorbent polymers: A review on the Characteristics and application of synthetic, polysachride-based, semi-synthetic and 'smart' derivatives.* European Polymer Journal, 2019. 117: 165-178

2. Sand A and Vyas A, *Superabsorbent polymer based on guar gum-graft-acrylamide: synthesis and characterization*. J Polym, 2020. Res 27: 43

3. Li X, He JZ, Hughes JM, Liu YR, Zheng YM, *Effects of super-absorbent polymers on a soil–wheat (Triticum aestivum L.) system in the field*. Appl Soil Ecol, 2014. 73:58–63

4. Laftah WA, Hashim S, Ibrahim AN, *Polymer hydrogels: A review*. Polym-Plast Technol Eng, 2011. 50:1475–1486

5. Cheng WM, Hu XM, Wang DM, Liu GH, *Preparation and characteristics of corn straw-co-amps-co-aa superabsorbent hydrogel.* Polymers,2015. 7: 2431–2445

6. Bardajee R.G, Pourjavadi A, Soleyman R, *Irradiation synthesis of Biopolymer based superabsorbent Hydrogel: Optimization using the Taguchi method and investigation of its swelling behavior.* Advances in Polymer Technology,2009. 28: 131-140

7. Sadeghi M and Hosseinzadeh H, *Synthesis and properties of Collagen-g-Poly (sodium acrylate-co-2-hydroxyethyl acrylate) superabsorbent hydrogel.* Brazilian Journal of Chemical Engineering, 2013.30: 379-389

8. Buchholz FL and Graham AT, *Modern Superabsorbent Polymer Technology. Wiley, Newyork* (1997)

9. Kazanskii KS and Dubrovskii SA, *Chemistry and Physics of Agricultural Hydrogels.* Advances in Polymer Science,1992. 104**:** 97-133

10. Kiatkamjornwong S and Suwanmala P *partially hydrolyzed polyacrylamide-poly(N-vinylpyrrolidone) copolymers as superabsorbents synthesized by gamma irradiation.* Journal of Applied Polymer Science,1998. **68:** 191-203

11. Kiatkamjornwong S and Wongwatthanasatien R, *Superabsorbentpolymer of poly[acrylamide-co-(acrylic acid)] by foamed polymerization. I. Synthesis and water swelling properties.* Macromolecular Symposia, 2004. **207:** 229-240.

12. Kidwell DA, *Superabsorbent Polymers - Media for the Enzymatic Detection of Ethyl-Alcohol in Urine.* Analytical Biochemistry, 1989. **182:**. 257-261.

13. Kilian W and Fanta J, *Degradation of forest sites and possibilities for theirrecovery.* Ecological Engineering, 1998. **10:**. 1-3.

14. Kim JH, Lee JH, and Yoon SW, *Preparation and swelling behavior of biodegradable superabsorbent gels based on polyaspartic acid.* Journal of Industrial and Engineering Chemistry, 2002. 8: 138-142.

15. Kimura T and Hikichi S, *pH-Dependence of the lower critical solution temperatures of random copolymers of N-isopropylacrylamide and itaconic acid.* Kobunshi Ronbunshu, 2000. 57: 730-733.

16. Kitch BT, Levy BD, and Fanta CH, *Late onset asthma - Epidemiology, diagnosis and treatment.* Drugs & Aging, 2000. **17:** 385-397.

17. Knaebel A, Rebre SR and Lequeux F, *Determination of the elasticmodulus of superabsorbent gel beads.* Polymer Gels and Networks, 1997. 5: 107-121.

18. Mechtcherine V, Reinhardt HW, STAR 225-SAP Application of Superabsorbent Polymers (SAP) in Concrete Construction; Springer Science & Business Media: Berlin, Germany, 2012.

19. Jensen OM, Hansen PF, *Water-entrained cement-based materials I. Principles and theoretical background.* Cem. Concr. Res., **2001**. 31: 647–654.

20. Jensen OM, Hansen PF, *Water-entrained cement-based materials II. Experimental observations.* Cem. Concr. Res., **2002**. 32: 973–978.

21. Dudziak L, Mechtcherine V, Hempel S, *Mitigating early age shrinkage of Ultra-High Performance Concrete by using Super Absorbent Polymers (SAP), Creep Shrinkage Durab*. Mech. Concr. Concr. Struct., **2009**. 847–853.

22. Kim JS, Schlangen E, *Super Absorbent Polymers to Stimulate Self Healing in Ecc. In Proceedings of the 2nd International Symposium on Service Life Design for Intrastructures (SLD2010),* Delft, The Netherlands, 2010. 849–858.

23. Van Tittelboom K, Snoeck, D, Wang J, De Belie N, *Most recent advances in the field of self-healing cementitious materials. In Proceedings of the ICSHM,* 4th International Conference Self-Healing Materials, Ghent, Belgium, 2013. 406–413.

24. Lee H, Wong HS, Buenfeld N, *Potential of superabsorbent polymer for self-sealing cracks in concrete.* Adv. Appl. Ceram, **2010**. 109: 296–302.

25. Tsuji M, Shitama K, Isobe D, *Basic Studies on Simplified Curing Technique, and Prevention of Initial Cracking and Leakage of Water through Cracks of Concrete by Applying Superabsorbent Polymers as New Concrete Admixture.* J. Soc. Mater. Sci. Jpn., **1999**. 1308–1315.

26. Snoeck D, Van Tittelboom K, Steuperaert S, Dubruel P, De Belie N, *Self-healing cementitious materials by the combination of microfibres and superabsorbent polymers.* J. Intell. Mater. Syst. Struct., **2012**. 25: 13–24.

27. Snoeck D, *Superabsorbent polymers to seal and heal cracks in cementitious materials.* RILEM Tech. Lett., **2018**. 3: 32–38.

28. Snoeck D, Steuperaert S, Van Tittelboom K, Dubruel P, De Belie N, *Visualization of water penetration in cementitious materials with superabsorbent polymers by means of neutron radiography.* Cem. Concr. Res, **2012**. 42: 1113–1121.

29. Monnig S, Lura P, *Superabsorbent Polymers—An Additive to Increase the Freeze-Thaw Resistance of High Strength Concrete.* Adv. Constr. Mater, **2007**. 351–358.

30. Mechtcherine V, Schrofl C, Wyrzykowski M, Gorges M, Lura P, Cusson D, Margeson J, De Belie N, Snoeck D, Ichimiya K et al. *Effect of superabsorbent polymers (SAP) on the freeze-thaw resistance of concrete: Results of a RILEM interlaboratory study.* Mater. Struct., **2017**. 50, 14.

31. Jensen OM, *Water absorption of superabsorbent polymers in a cementitious environment. In Proceedings of the International RILEM Conference on Advances in Construction Materials through Science and Engineering,* Hong Kong, China, 2011. 22–35.

32. Chen X, Shan G, Huang J, Huang Z, Weng Z, *Synthesis and Properties of Acrylic-Based Superabsorbent.* J. Appl. Polym. Sci, **2004**. 92: 619–624.

33. Runeman B, *Skin interaction with absorbent hygiene products.* Clinics in Dermatology, 2008. 26: 45-51.

34. Buchholz FL, *A Swell Idea - Superabsorbent Polymers.* Chemistry in Britain, 1994. 30: 652-656.

35. Zhao YL, Fang and Tan TW, *Optimization of the preparation of a poly(aspartic acid) superabsorbent resin with response surface methodology.* Journal of Applied Polymer Science, 2006.**,** 2616-2622.

36. Higuchi A and Iijima T, *Permeation of Solutes in Water-Swollen PolyvinylAlcohol-Co-Itaconic Acid) Membranes.* Journal of Applied Polymer Science, 1986. 32: 3229-3237.

37. Fanta GF, Babcock GE, and Burr RC, *Copolymers of Starch and Polyacrylonitrile - Soluble Fraction.* Journal of Polymer Science Part a-1-Polymer Chemistry, 1969. 7: 980

38. Sunithaa K, Sadhanab R, Mathewa Dona & Reghunadhan CP Naira, *Novel superabsorbent copolymers of partially neutralized methacrylic acid and acrylonitrile: synthesis, characterization and swelling characteristics.* Monomers and Polymers,2015. DOI: 10.1080

39. Siegel RA, Firestone BA, *pH-dependent equilibrium swelling properties of hydrophobic polyelectrolyte copolymer gels.* Macromolecules, 1988. 21:3254–3259.

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